Excavation and grouting works of the new underground powerhouse of Veytaux 2

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The Hongrin Léman power plant belonging to Forces Motrices Hongrin Léman, FMHL, is a 240 MW pumped storage power plant in Canton Vaud, Switzerland. The current installed capacity is under extension to 480 MW with a maximal output power set to 420 MW and 60 MW of reserve. This project, named FMHL+, consists in developing a new powerhouse called Veytaux 2 to be operated in parallel to the existing Veytaux 1 powerhouse and connected to the same adduction system

The Owners of FMHL+ projects are Romande Energie SA, ALPIQ Suisse SA, Groupe e and City of Lausanne. The project and erection is lead by ALPIQ Suisse SA, which awarded the project design to the GIHLEM consortium, constituted by Stucky SA, EDF-CIH and Emch-Berger engineering companies. The geological follow-up was performed by Norbert SA.

Stucky SA is responsible for the powerhouse and deal with excavation and support, monitoring, drilling and grouting works as well as concrete works. The new underground powerhouse of Veytaux 2, currently under construction, will have a length of 100 m, a width of 25 m and a height of 56 m. The last 35 m are located below the underground water level, in direct connection with the lake of Geneva. The rock mass is composed of hard, thick bedded marly limestones with calcareous schist and clayey schist horizons. Three joints sets were identified and the stratification is subhorizontal. The rock cover above the crown varies from 80 to 120 m.

The following Figure 1 shows a typical cross-section of the new powerhouse of Veytaux 2, with the passive anchors pattern and the grout curtain (in grey)

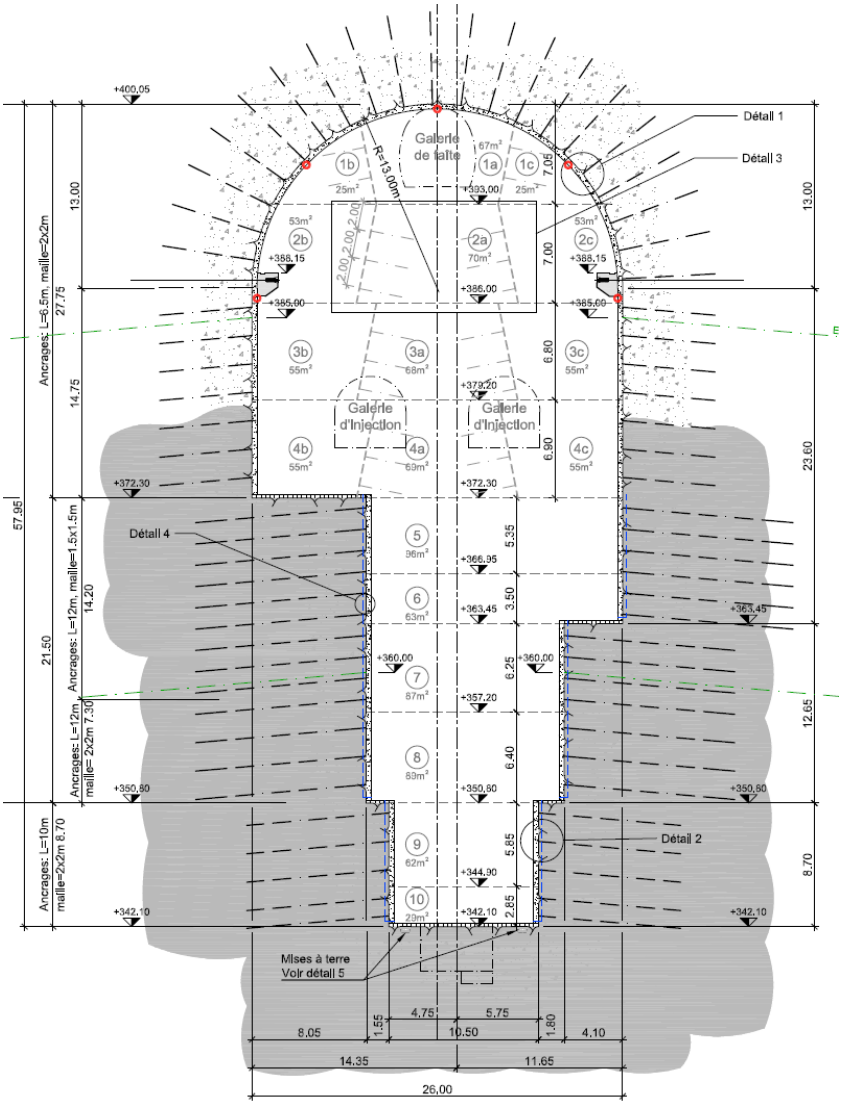

Figure 1: Cross-section of the new powerhouse of Veytaux 2

A total of ten excavation stages, by means of the drill and blast method, will be executed to reach the bottom level. In the preliminary studies, the rock support was designed according to empirical methods, whereas for the final design, a finite elements model was used. This model confirmed that the rock support initially chosen was suitable. The rock mass quality is fair to good. Passive anchors, shotcrete and wire mesh were used for the rock support. No prestressed anchors were required.

The excavation follow-up was ensured by a monitoring system consisting of rod extensometers and convergence measurements. A thorough geological follow-up was carried out and showed that the rock mass quality was in accordance with the expectations from the geological investigations report. The as-built finite elements model confirmed that the displacements measured were consistent with the model predictions and no additional support was required.

The permeability of the fractured rock mass is in the magnitude of $k = 10^{-4}$ m/s. At the end of the stage 3, drilling and grouting works have been performed, in order to limit the water inflows for the next stages that were below the underground water level. A grout curtain of 10m thick has been carried out all around the powerhouse, with a water-cement grout mix. The Grout Intensity Number (GIN Method) was used, with primary, secondary and tertiary holes. Locally, quaternary holes have been required.

Excavation of the cavern started on 19th October 2011. Between January and May 2013, only the drilling and grouting works were carried out. To date, the excavation of the last two stages has just started. Around 150'000 m^3 of materials have been excavated, 58'000 m of holes for grouting have been drilled and the total cement consumption was 2350 t, which lead to an average grout consumption of 40 kg/m.

Picture 1 (left) : Powerhouse excavation at stage 1 11th January 2012 (picture from www.fmhl.ch)

Picture 2 (right): Powerhouse excavation at stage 8 8th November 2013 (picture from www.fmhl.ch)

Up to now, the monitoring results show an expected behavior of the rock mass and the small amount of inflow seepage witnesses the success of the grouting works. The excavation will be completed at the end of January 2014 and will be followed by the structural concrete works. Energy production is expected to start at the end of 2015.